Reply to "Comment on "Lateral Casimir Force beyond the Proximity Force Approximation" "

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Our letter [1] is devoted to the presentation of a novel theoretical approach to the lateral Casimir force beyond the regime of validity of the "Proximity Force Approximation" (PFA). The approach relies on scattering theory used in a perturbative expansion [2] valid when the corrugation amplitudes a_1, a_2 are smaller than the 3 other length scales, the mean separation distance L, the corrugation period λ_C and the plasma wavelength λ_P. This restriction is repeatedly stressed in the abstract and the body text of [1] and it is also the main topic of the comment [3]. We agree with the statements in the comment which constitute yet another warning that the calculations presented in [1] are valid "provided that the corrugation amplitude is smaller than the other length scales" (last sentence of [1]). But we strongly disagree with the idea that the approach in Ref. [1] is not appropriate for making statements on the accuracy of the PFA.

It was natural to illustrate the results of the new approach by applying them to a comparison with the experiment reported in Refs. [4]. As the corrugation amplitudes in the experiment are smaller, but not much smaller, than the other length scales, the comparison could unfortunately not be direct, as explained as fairly as possible in [1]. The results of [1] are however of clear interest for the experiment, as they can be summed up as follows, assuming that L, λ_C, λ_P are chosen in accordance with the experimental numbers [4] : i) the perturbative calculation beyond the PFA [1] gives a force approximately 40% smaller than the perturbative calculation within the PFA; ii) as the calculation of Refs. [4] takes into account higher order powers in $a_1 a_2$ (which is easy within the PFA), we extracted the perturbative result (proportional to $a_1 a_2$) by discarding the higher orders contribution; this procedure produced a discrepancy of approximately 30% between the two methods. This number points to a potential concern for theory-experiment comparison, which is nevertheless not so severe as the experimental results (0.32 ± 0.077pN according to [3]) correspond to a relative accuracy of $\pm 24\%$.

The focus of the comment [3] is an argument about our estimation of the discrepancy. The comment sidesteps the issue by comparing two numbers which are *not* to be compared (and which we did *not* compare), namely the perturbative result beyond the PFA and the non perturbative result within the PFA. It thus fabricates a large discrepancy (nearly 60%) which would make the concern more severe. We certainly do not approve this way of comparison since there is not any reason to ignore the effect of higher order corrections in one calculation and take it into account in the other one. More work is needed in order to settle the issue of theory-experiment comparison.

Progress on this question could be achieved by calculating higher order corrections for metallic mirrors beyond the PFA. These corrections are expected to affect the numbers, but they will hardly compensate exactly the deviation from the PFA demonstrated in the perturbative regime. Let us underline at this point that the second paragraph of the comment [3], aimed at raising doubts on the predictions of [1], is based on a mistake. The factor ρ, which measures the deviation from the PFA, is a function of the *three* length scales L, λ_C, λ_P, which is calculated in [1] for metallic mirrors. The case of perfectly reflecting mirrors is recovered in the limit $\lambda_P \to 0$ but, in contrast with what is stated in [3], the general function cannot be reconstructed from this particular limit.

Progress could alternatively come for experiments using smaller corrugation amplitudes while showing a better experimental accuracy. The first condition would aim at reaching the condition $a_1, a_2 \ll L, \lambda_C, \lambda_P$ which delineates the range of validity of the theoretical predictions of [1]. As emphasized in the conclusion of our letter, this would make possible "an accurate comparison between theory and experiment in a configuration where geometry plays a non trivial role, *i.e.* beyond the PFA." Meanwhile, an improved accuracy would allow to compare experiment with different theoretical predictions.

[1] R.B. Rodrigues, P.A. Maia Neto, A. Lambrecht and S. Reynaud, Phys. Rev. Lett. **96**, 100402 (2006).

[2] P.A. Maia Neto, A. Lambrecht and S. Reynaud, Europhys. Lett. **69**, 924 (2005); Phys. Rev. **A 72**, 012115 (2005).

[3] F. Chen, U. Mohideen, G.L. Klimchtskaya and V.M. Mostepanenko, "Comment on [1]", submitted to Phys. Rev. Lett.

[4] F. Chen, U. Mohideen, G.L. Klimchtskaya and V.M. Mostepanenko, Phys. Rev. Lett. **88**, 101801 (2002); Phys. Rev. **A 66**, 032113 (2002).